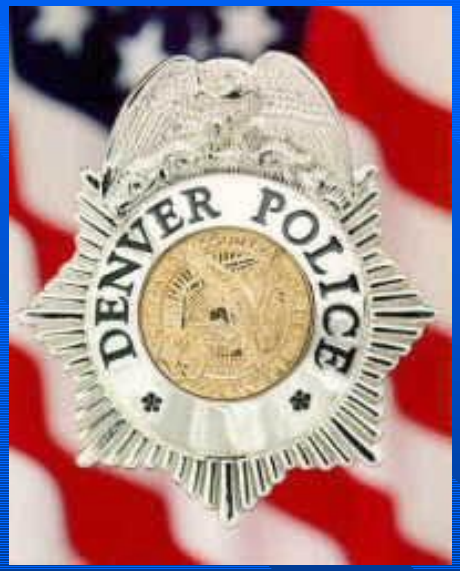
800 MHz Interference In Denver, CO

September 16, 2003



Prepared by

Pericle Communications Company
1910 Vindicator Drive, Suite 100
Colorado Springs, CO 80919

For

The Federal Communications Commission

Outline

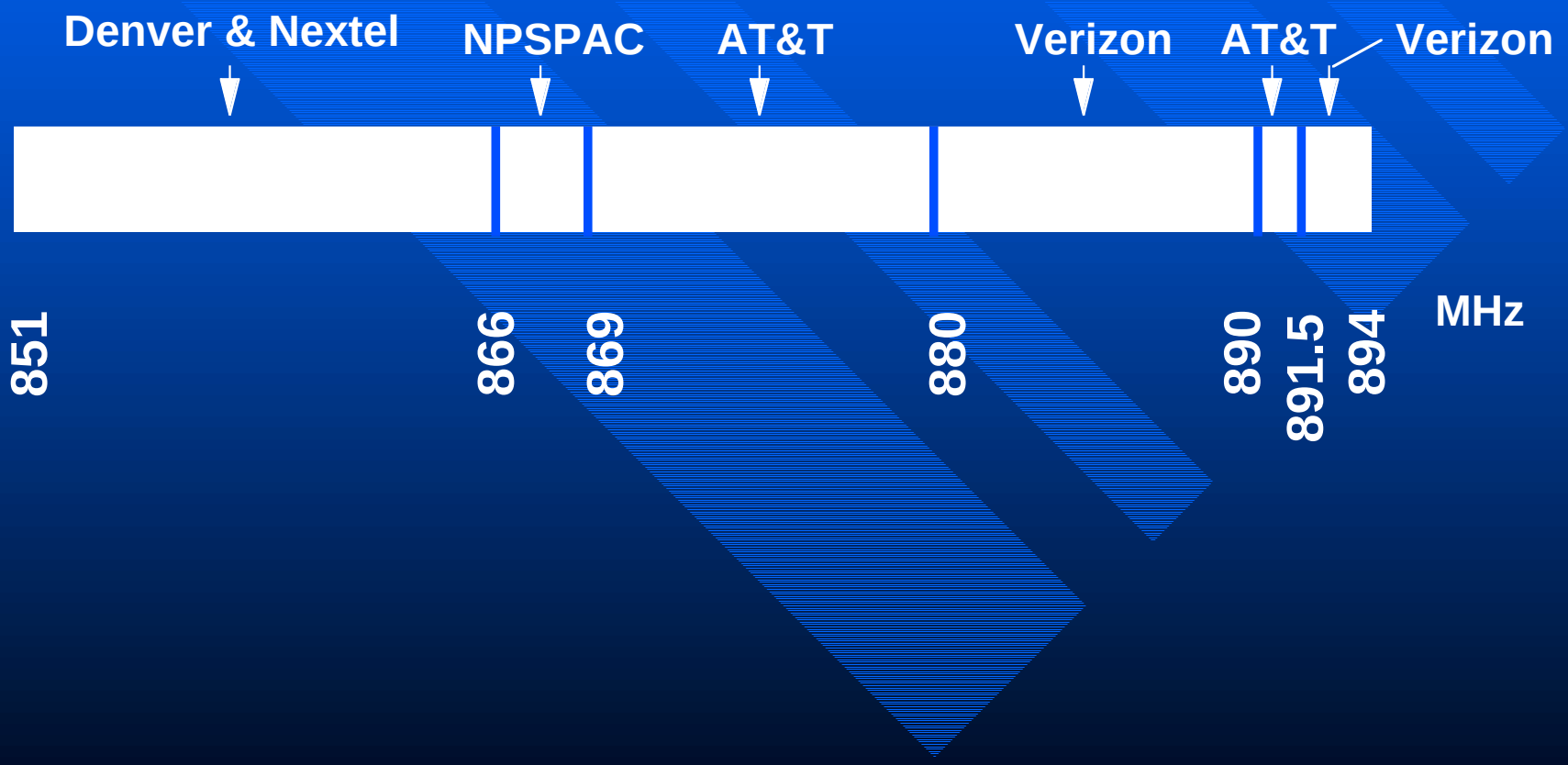
- **The Denver/Nextel Problem**
  - Nature of the interference
  - Techniques used to mitigate it
  - Relative success of the effort
- **AT&T's Contribution to the Problem**
  - Why it occurs
  - Extent of AT&T's contribution
- **Why "Technical Toolbox" is Inadequate**

The Denver Problem

Denver Public Safety Radio

- **Frequencies**
  - Public Safety: 33 channels, 854-861, 866-869 MHz
  - Utilities: 15 channels (25 kHz), 854-861 MHz
- **Equipment**
  - MA/COM EDACS Trunked Radio System/Analog FM
  - Activated 1989
- **Site**
  - Main transmitter site on Mt. Morrison (7,750’ AMSL)

Denver 800 MHz Band



Background

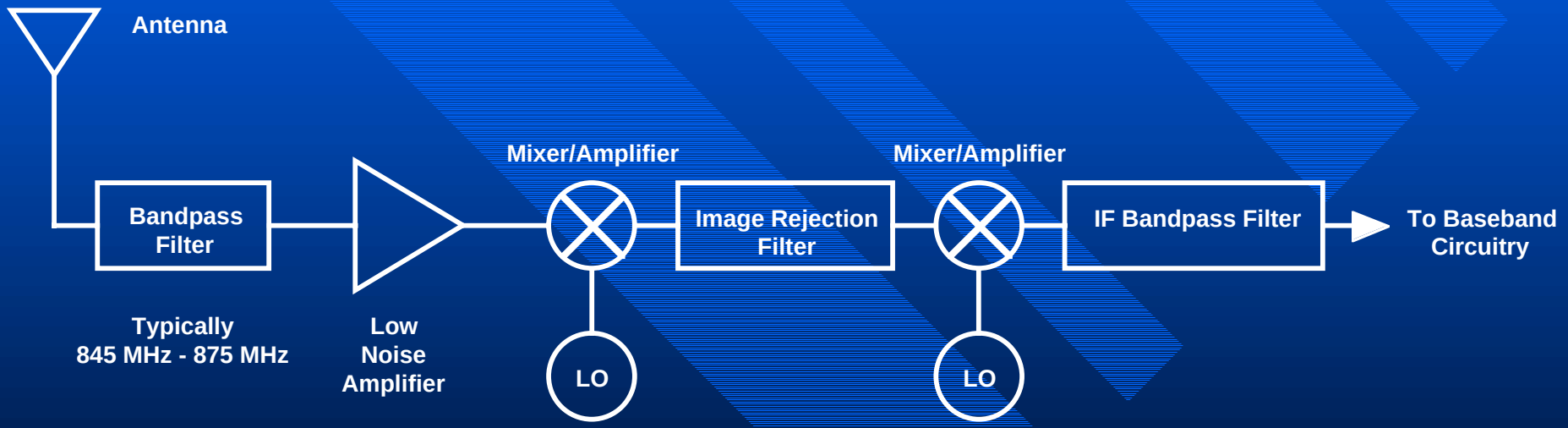
- Problem Discovered in Feb 2000 Following Officer Complaints
- Discovered Nextel Cell Site Near Each Location
- Eventually 24 Sites Identified
- Two Main Problems:
  - Receiver Intermodulation in Public Safety Receiver
  - Transmitter out -of-band emissions from Nextel transmitter
- Actions Taken & Proposed
  - Near-term: mitigation
  - Long-term: a phased channel swap and re-banding

Problem Mitigation
Intermodulation (IM) Protection

- Actions
  - "Tune" Nextel site to preclude harmful IM products
  - Practically, only some Denver channels can be protected
  - Control channel is most important
  - Limit control channels to first five RF channels
  - Nextel protects just these five channels
- Results
  - Effective at roughly 18 of 24 problem sites
- Limitations
  - Only control channels are protected
  - Voice channels still experience interference
  - System often assigns user to a bad voice channel (one with IM)
  - Nextel limited in use of their spectrum

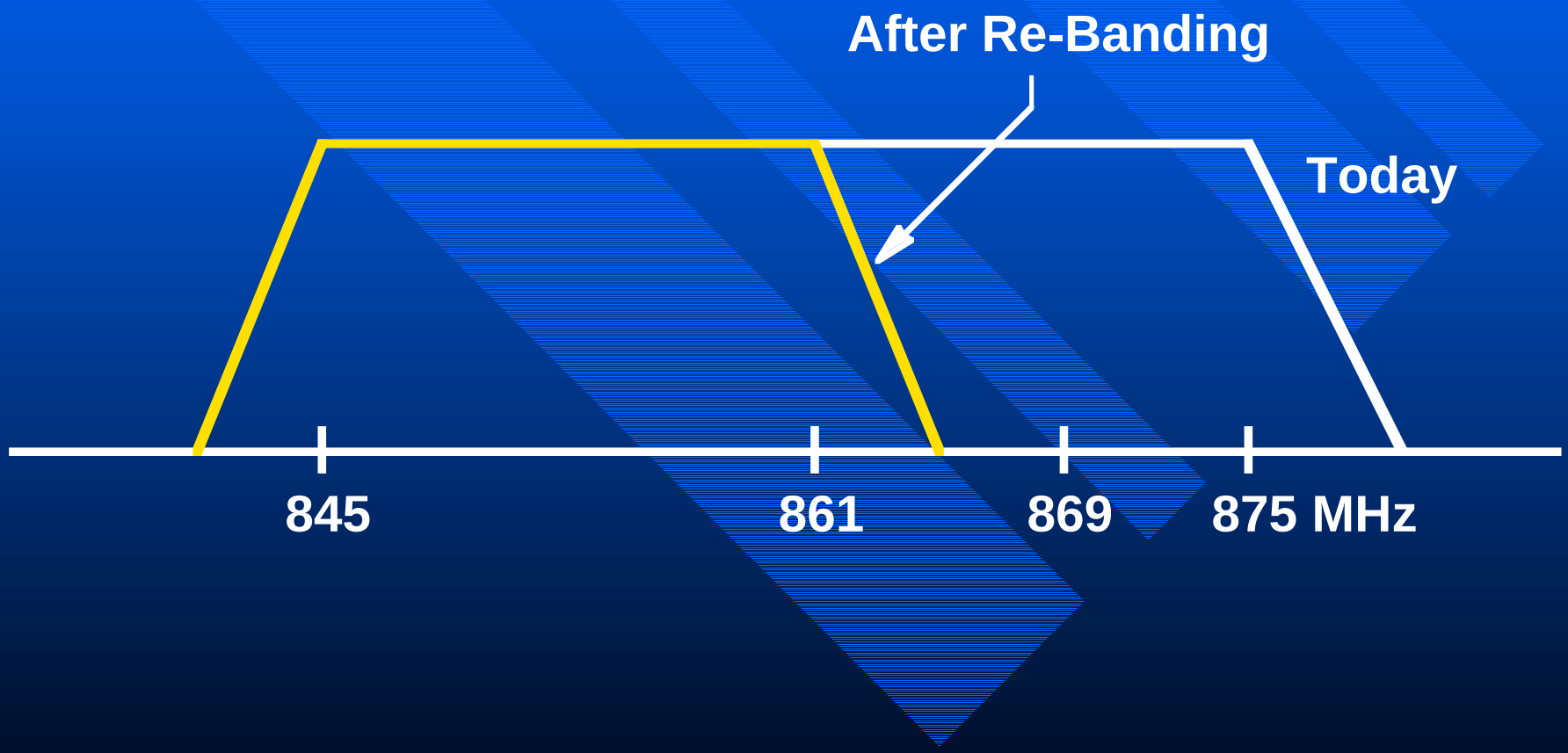
Public Safety Receiver

- At low levels, IM rejection driven by mixer performance
- At high levels (> -40 dBm), IM rejection driven by LNA
- Bandpass Filter Passes All of SMR, Most of A-Band Cellular



Filter Comparison

(Public Safety Receiver)

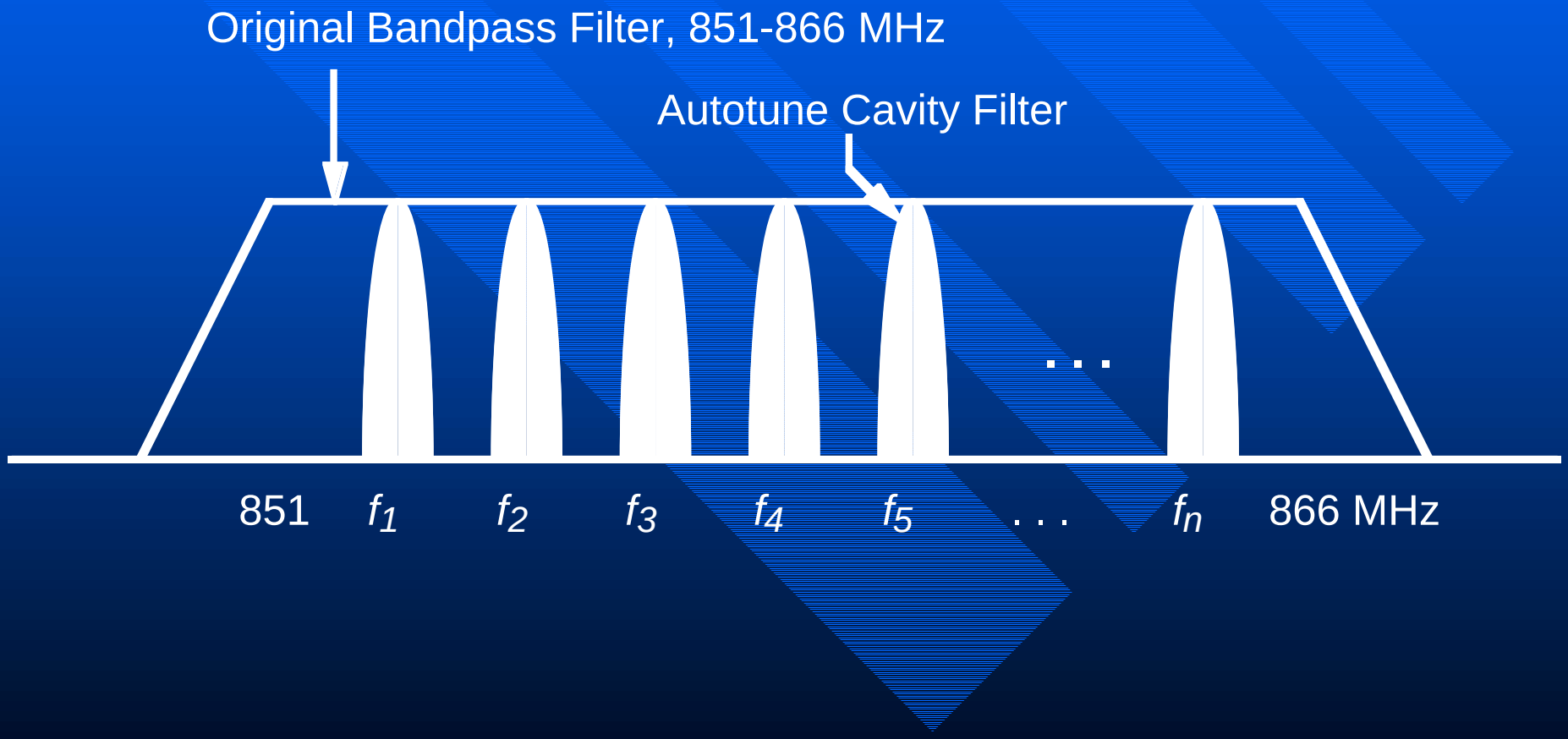


Problem Mitigation
Transmitter Out of Band Emissions (OOBE)

- **Actions**
  - Nextel installed auto-tune cavity combiners
  - Greater filter selectivity reduces out-of-band emissions
- **Results**
  - Effective when channel separation is wide enough
- **Limitations**
  - Not effective for closely spaced frequencies (< 150 kHz)

Filter Comparison

(Nextel Transmitter Combiner)



Problem Mitigation
Antenna Patterns

- **Actions**
  - Nextel installed antennas with reduced downward radiation
- **Results**
  - Reduces Nextel signal level on the street
  - Intermodulation products reduced by roughly 3 to 1 ratio in dB
- **Limitations**
  - Signal still too strong at some locations
  - Some loss of indoor coverage close-in for Nextel

AT&T Wireless

Problem Statement

- **After Mitigation, Six Sites Remained a Serious Problem***
  - **Five of the six were co-located Nextel/AT&T Wireless**
  - **Mathematically, AT&T can contribute to receiver IM**
  - **IM can be AT&T alone (NPSPAC mostly) or with Nextel**
- **Task: Determine if AT&T is Contributing to Problem**

***These are the "red" sites. Denver also has lesser problems at several "yellow" sites.**

Observations - AT&T

- Factors Contributing to Interference
  - AT&T is adjacent to NPSPAC band (869-880, 890-891.5 MHz)
  - Numerous theoretical IM “hits” on Denver NPSPAC channels
  - Numerous “hits” with Nextel frequencies in 855 MHz region
  - Denver receivers do not attenuate below 875 MHz
  - AT&T base stations pass transmitter noise below 869 MHz
- Mitigating Factors
  - Signal levels on street are lower than Nextel (in general)
  - Location in 800 MHz band limits AT&T 3rd order products
  - Most likely products are combinations with Nextel
  - Frequencies above 875 MHz attenuated (for some radios)
  - Transmitters not keyed continuously

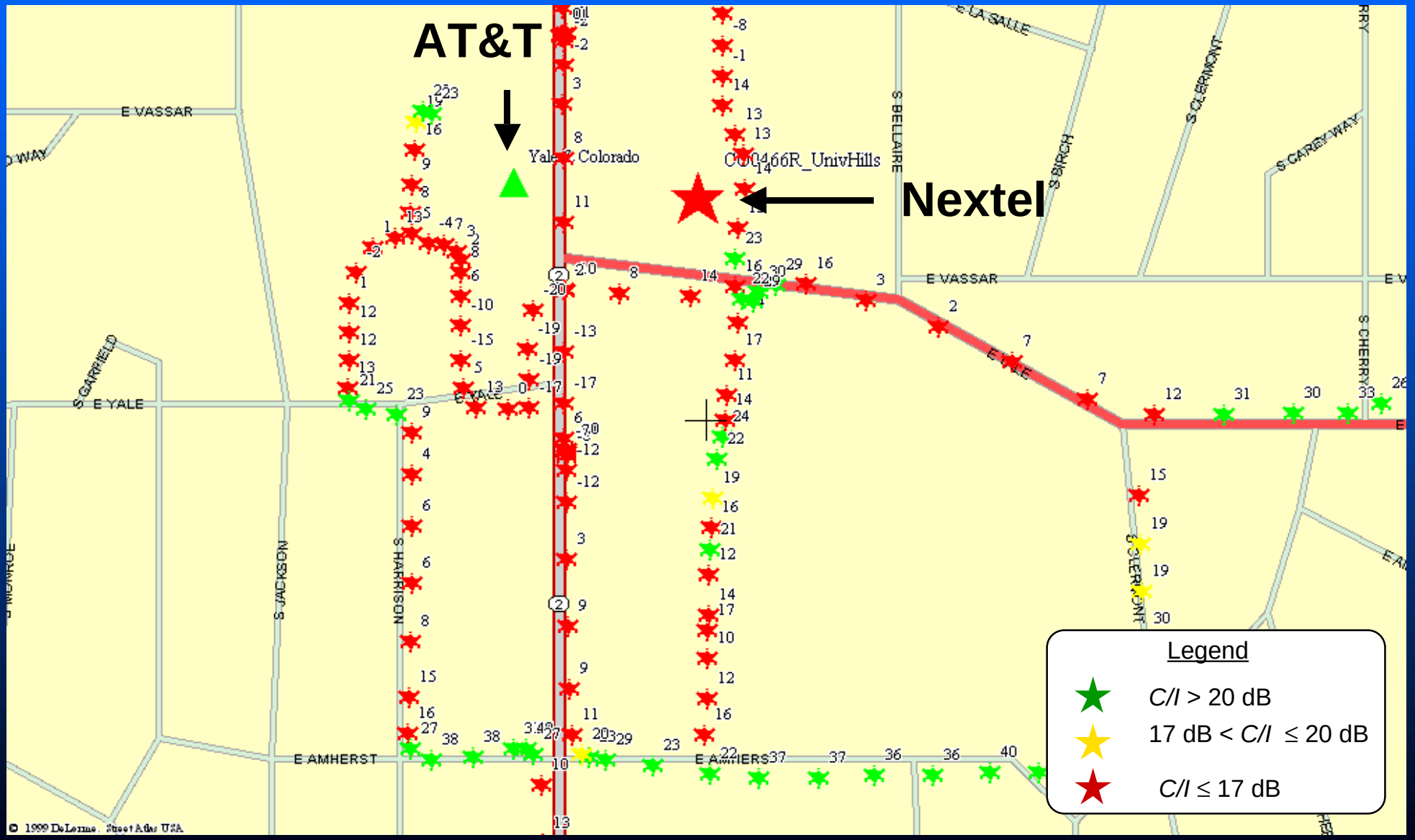
Example: Yale & Colorado

Nextel Site
(East Side)

AT&T Site
(West Side, north
of Fire House)

Denver Fire House
(West Side)

Yale & Colorado



On-Off Testing

- First, Conduct Intermodulation (IM) Study
  - Consider all 3rd order products with AT&T & Nextel
  - Only first five Denver channels considered (control channels)
- Second, Use IM Study to Configure On-Off Test
  - Limit keyed AT&T frequencies so only known IM products occur
  - I.e., assures cause and effect conclusion is correct
- Finally, Walk the Area Under On and Off Conditions
  - Verifies that AT&T is or is not a contributor

AT&T Results

- **AT&T Wireless Contributes to Receiver IM**
  - **Predicted mathematically, confirmed by On-Off tests**
- **Most IM Products Require Nextel Also**
  - **I.e., IM that falls on five control channels**
- **Note: Does not Include NPSPAC Interference**
  - **NPSPAC (866-869 MHz) does occur with AT&T alone**

Why The “Technical Toolbox” is Inadequate

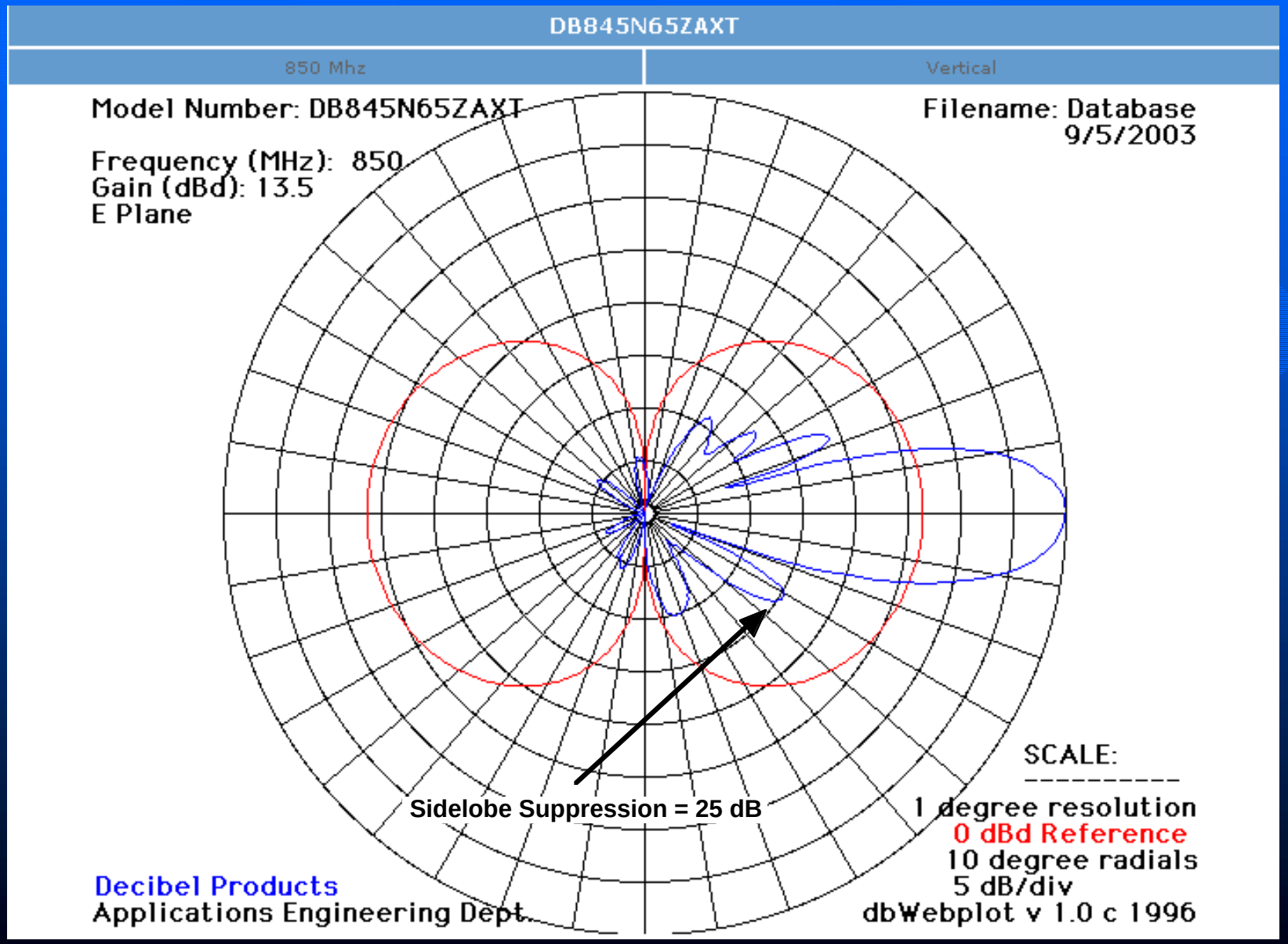
The “Technical Toolbox”

- Tools Already In Service in Denver:
  - IM Tuning at Nextel Sites
  - Auto-tune cavity combiners
  - Antennas with less downward radiation
- Varactor Bandpass Filters
- Switchable Attenuator
- Why Can’t These Tools Do the Job Without Re-banding?

The “Technical Toolbox”

- **IM Tuning**
  - Limits Nextel’s frequency choices too much
  - Only practical to protect a handful of frequencies (control ch’s)
  - At congested sites, we still have strong IM on traffic channels
  - Nextel alone can’t control the Nextel/AT&T mixes
- **Auto-Tune Cavity Combiners**
  - Cavities have finite isolation
  - Not good for close-in channels (< 150 kHz)
  - Further limits Nextel’s frequency choices
- **Antenna Patterns**
  - See REMEC FCC comments
  - They have right idea, but we are already doing this

Antenna Used in Denver



Antenna Issues

- Tried Sidelobe Suppression at Two Sites:
  - City Bank, 8-10 stories high, good results
  - 14th & Market, ~ 3 stories high, not effective
- Only works on relatively high sites (look down angle issue)
- Higher gain, narrower beamwidth antennas best
  - High gain antennas are taller
  - But zoning restrictions limit antenna height

It’s Usually the Low Site

(Alameda & Federal)

Another Low Site (48th & Elm)

The “Technical Toolbox”

- **Varactor-Tuned Bandpass Filters**
  - Motorola suggestion
  - Good idea, but cannot help if channels are interleaved
- **Switchable Attenuator**
  - Motorola suggestion
  - Cannot distinguish between IM and receiver overload
  - In most cases, will unnecessarily degrade sensitivity by 15 dB
  - But the problem occurs at -90 to -110 dBm
  - Cannot afford a 15 dB hit in sensitivity at these levels
  - Introduces complex signal estimation problems
  - Still a research project, not a field tested product

Why Denver Needs Re-Banding

- Denver Has Tried the “Technical Toolbox” for 3 Years
  - Only partial improvements
  - These are stop-gap measures
- The Problem Will Only Get Worse
  - Nextel & AT&T will continue to build sites with low antenna heights
- Only Re-Banding will Solve the OOBE Issue
- Receiver Technology Will Not Save Us
  - Amplifier & mixer technology is mature
  - No significant advances on the horizon
- Filtering at Receivers & Transmitters Only Effective w/Re-Banding

Points of Contact

Jay M. Jacobsmeyer, P.E.
Pericle Communications Company
1910 Vindicator Drive, Suite 100
Colorado Springs, CO 80919
(719) 548-1040
Fax: (719) 548-1211
jacobsmeyer@pericle.com

George W. Weimer, P.E.
Trott Communications Group, Inc.
1425 Greenway Drive, Suite 350
Irving, TX 75038
(972) 580-1911
Fax: (972) 580-0641
george.weimer@trottgroup.com